**Regional Information Report No. 5J08-04**

# Long-Term Alaskan Crab Research Priorities Preliminary Draft Update, 2008

**by**

**Joel Webb**

**and**

**Doug Woodby**

**July 2008**

**Alaska Department of Fish and Game** **Division of Commercial Fisheries**

## Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, Special Publications and the Division of Commercial Fisheries Regional Reports. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

**Weights and measures (metric)**

| | |
|---|---|
| centimeter | cm |
| deciliter | dL |
| gram | g |
| hectare | ha |
| kilogram | kg |
| kilometer | km |
| liter | L |
| meter | m |
| milliliter | mL |
| millimeter | mm |

**Weights and measures (English)**

| | |
|---|---|
| cubic feet per second | $ft^3/s$ |
| foot | ft |
| gallon | gal |
| inch | in |
| mile | mi |
| nautical mile | nmi |
| ounce | oz |
| pound | lb |
| quart | qt |
| yard | yd |

**Time and temperature**

| | |
|---|---|
| day | d |
| degrees Celsius | °C |
| degrees Fahrenheit | °F |
| degrees kelvin | K |
| hour | h |
| minute | min |
| second | s |

**Physics and chemistry**

| | |
|---|---|
| all atomic symbols | |
| alternating current | AC |
| ampere | A |
| calorie | cal |
| direct current | DC |
| hertz | Hz |
| horsepower | hp |
| hydrogen ion activity (negative log of) | pH |
| parts per million | ppm |
| parts per thousand | ppt, ‰ |
| volts | V |
| watts | W |

**General**

| | |
|---|---|
| Alaska Administrative Code | AAC |
| all commonly accepted abbreviations | e.g., Mr., Mrs., AM, PM, etc. |
| all commonly accepted professional titles | e.g., Dr., Ph.D., R.N., etc. |
| at | @ |
| compass directions: | |
| east | E |
| north | N |
| south | S |
| west | W |
| copyright | © |
| corporate suffixes: | |
| Company | Co. |
| Corporation | Corp. |
| Incorporated | Inc. |
| Limited | Ltd. |
| District of Columbia | D.C. |
| et alii (and others) | et al. |
| et cetera (and so forth) | etc. |
| exempli gratia (for example) | e.g. |
| Federal Information Code | FIC |
| id est (that is) | i.e. |
| latitude or longitude | lat. or long. |
| monetary symbols (U.S.) | $, ¢ |
| months (tables and figures): first three letters | Jan,...,Dec |
| registered trademark | ® |
| trademark | ™ |
| United States (adjective) | U.S. |
| United States of America (noun) | USA |
| U.S.C. | United States Code |
| U.S. state | use two-letter abbreviations (e.g., AK, WA) |

**Measures (fisheries)**

| | |
|---|---|
| fork length | FL |
| mideye-to-fork | MEF |
| mideye-to-tail-fork | METF |
| standard length | SL |
| total length | TL |

**Mathematics, statistics**

| | |
|---|---|
| *all standard mathematical signs, symbols and abbreviations* | |
| alternate hypothesis | $H_A$ |
| base of natural logarithm | *e* |
| catch per unit effort | CPUE |
| coefficient of variation | CV |
| common test statistics | (F, t, $\chi^2$, etc.) |
| confidence interval | CI |
| correlation coefficient (multiple) | R |
| correlation coefficient (simple) | r |
| covariance | cov |
| degree (angular ) | ° |
| degrees of freedom | df |
| expected value | *E* |
| greater than | > |
| greater than or equal to | ≥ |
| harvest per unit effort | HPUE |
| less than | < |
| less than or equal to | ≤ |
| logarithm (natural) | ln |
| logarithm (base 10) | log |
| logarithm (specify base) | $log_2$, etc. |
| minute (angular) | ' |
| not significant | NS |
| null hypothesis | $H_O$ |
| percent | % |
| probability | P |
| probability of a type I error (rejection of the null hypothesis when true) | α |
| probability of a type II error (acceptance of the null hypothesis when false) | β |
| second (angular) | " |
| standard deviation | SD |
| standard error | SE |
| variance | |
| population | Var |
| sample | var |

# *REGIONAL INFORMANTION REPORT NO. 5J08-04*

# LONG-TERM ALASKAN CRAB RESEARCH PRIORITIES PRELIMINARY DRAFT UPDATE, 2008


By
Joel Webb
Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau
and
Doug Woodby
Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau



Alaska Department of Fish and Game
Division of Commercial Fisheries
1255 W. 8th St. P. O. Box 115526, Juneau, AK 99811-5523

July 2008

The Regional Information Report Series was established in 1987 and was redefined in 2006 to meet the Division of Commercial Fisheries regional need for publishing and archiving information such as project operational plans, area management plans, budgetary information, staff comments and opinions to Board of Fisheries proposals, interim or preliminary data and grant agency reports, special meeting or minor workshop results and other regional information not generally reported elsewhere. Reports in this series may contain raw data and preliminary results. Reports in this series receive varying degrees of regional, biometric and editorial review; information in this series may be subsequently finalized and published in a different department reporting series or in the formal literature. Please contact the author or the Division of Commercial Fisheries if in doubt of the level of review or preliminary nature of the data reported. Regional Information Reports are available through the Alaska State Library and on the Internet at: http://www.sf.adfg.ak.us/statewide/divreprots/htlm/intersearch.cfm.

*Joel Webb*
*Alaska Department of Fish and Game, Division of Commercial Fisheries*
*1255 W. 8th St. P. O. Box 115526, Juneau, AK 99811-5525*

*Doug Woodby,*
*Alaska Department of Fish and Game, Division of Commercial Fisheries*
*1255 W. 8th St. P. O. Box 115526, Juneau, AK 99811-5525*

*This document should be cited as:*
*Webb, J., and D. Woodby 2008. Long-Term Alaskan Crab Research Priorities Preliminary Draft Update, 2008. Alaska Department of Fish and Game, Regional Report Series No. 5J08-04, Juneau.*

# TABLE OF CONTENTS

**Page**

# ABSTRACT

Crab research priorities were updated after discussion at the 2007 Interagency Crab Meeting in Anchorage, Alaska and further written feedback from state and federal stakeholders. Stocks identified by stakeholders as having priority needs are listed in parentheses following the respective research priority.

Key Words: crab, research, stock, population, genetics, catchability, population estimation models, mortality, growth, reproduction, settlement, recruitment, habitat, diseases, parasites, gear, harvest, surveys

# STOCK STRUCTURE

## GENETICS

1. Develop a program to assess the contribution of Tanner-snow hybrids to the Bering Sea crab fishery integrating genetic studies and field identifications.
2. Continue and improve genetic stock identification studies with microsatellite or Single Nucleotide Polymorphism (SNP) studies for all crabs.
3. Use nucleotide sequence analysis (microsatellite or SNPs) to infer demographic histories and stock boundaries of crabs in Alaska (Bristol Bay, Gulf of Alaska, northern Bering Sea, and Southeast Alaska red king crab; Northern Bering Sea, Pribilof Islands, and St. Matthew Island blue king crab).
4. Relate genetic structure to shoreline complexity, ocean currents, bathymetry, and geographic distance.
5. Combine genetic and ecological data in a rigorous sampling design to infer larval and adult dispersal distances and gene flow over ecological and evolutionary time frames.
6. Use landscape genetics approach and rigorous, intense sampling design to determine physical and biological factors influencing hybridization and gene flow between stocks.

## OTHER

7. Evaluate the degree to which surveyed stocks overlap with fished stocks; e.g., develop a tag release and recapture program for investigating relationships of snow crabs in the northern Bering Sea to snow crabs on the fishing grounds.
8. Determine annual and long-term movements of crabs and how these migrations affect population structure (Aleutian Islands, Pribilof Islands, and Southeast Alaska golden king crab).
9. Use morphological characteristics to distinguish species, hybrids, stocks, and instars; develop for field use, a weatherproof computer imaging system based on these characteristics.
10. Examine molecular genetic variability in newly exploited stocks to help define management areas.

# POPULATION ESTIMATION

## SURVEYS

1. Implement or enhance surveys for crab stocks that are currently unsurveyed or have low survey precision (Aleutian Islands golden king crab west of 174, Aleutian Islands red king crab, grooved Tanner crab, Gulf of Alaska Dungeness crabs, and Southeast Alaska golden king crab).
2. Develop methods to make existing surveys more efficient. Examples include electronic data collection and combining surveys for multiple species into combined surveys.
3. Supplement trawl surveys with pot surveys or other data.
    a. Incorporate ADF&G Bristol Bay red king crab test fishery data and tag recoveries into current stock assessment.
    b. Reinstitute annual or biennial ADF&G Bristol Bay red king crab pot survey.
    c. Supplement Gulf of Alaska Tanner trawl database with pot surveys.
    d. Supplement/adjust surveys to increase precision for Kodiak Island red king crab.
4. Evaluate the effectiveness of surveys and develop methods to improve surveys.
    a. Use historic data to set sample size and establish sampling strata based on information such as depth and habitat.
    b. Assess the effect of timing of survey and crab distribution relative to fishery.
    c. Use benthic habitat information (e.g. from sidescan sonar) to establish sampling strata and increase survey precision (Southeast Alaska Tanner crab).
5. Experiment with use of mark–recapture and Leslie Depletion estimators to estimate population sizes (Southeast Alaska golden king crab).

## CATCHABILITY

6. Estimate crab pot catchability and selectivity coefficients (Tanner, snow, and female red king crabs).
    a. Use a combination of tagging and fishing down the stock in a limited area.
    b. Assess the effects of the size, sex, and species of crabs already caught on catches of additional crabs.
    c. Assess the variability in catch over time for pots and understand what factors can effect the catch over time.
    d. Assess the role of different baiting techniques on catchability including the use of sonic bait.
7. Estimate relative catchability and selectivity of trawls. Possible methods of approach include depletion estimators, change in ratio estimators, visual estimates with trawl mounted cameras, further use of ‘underbags’ or tickler chains, remote operated vehicles, laser line scanning system, and mark–recapture methods.
    a. Bristol Bay red king crabs size and sex.

b. Westward survey for Tanner crab size, sex, and shell condition.

c. NMFS trawl for snow and Tanner size, sex, and shell condition.

### Database Management

8. Complete historical data documentation and computer entry of state shellfish data.
9. Complete development and deployment of a metadata storage system for shellfish data.

### Alternative Population Estimation Methods

10. Apply recent advances in population estimation models to surveyed crab stocks. Potentially applicable models are catch-survey analyses, length-based analyses, and stock synthesis (Aleutian Islands golden king crabs, Gulf of Alaska Dungeness and Tanner crabs; Southeast Alaska Dungeness and Tanner crabs).
11. Continue to develop and test analytical methods to estimate abundance of unsurveyed stocks, including the use of observer data.
12. Assess the cost effectiveness of passive integrated transponder (PIT) tag mark–recapture methods (dependent on improvements in cost effectiveness of the technology of recapture) to estimate exploitation rates and population sizes.
13. Develop spatial models and multi-species models for crab stocks (Bering Sea Tanner crab).

## STOCK PRODUCTIVITY

### Natural Mortality

1. Study the contributions of disease to mortality.
2. Investigate the relationship of mortality to molting, spawning, and sex of crab.
3. Study potential relationships between shell condition and mortality.
4. Estimate predation mortality on different life history stages of crabs.
5. Evaluate the effect of physical factors, such as temperature or salinity, on mortality.
6. Continue to estimate mortality for all Alaskan crab species, including examination of tag-recapture data.
7. Assess the variation of mortality within and between years and evaluate the effect of this variation on population models.
8. Examine causes of high mortality of Bristol Bay red king crabs in the early 1980s.
9. Estimate contribution of cannibalism on juvenile mortality rates, especially for snow and Tanner crabs.
10. Use diet studies and trophic dynamics modeling to investigate mortality due to trophic level interactions especially the contribution of fish predation to juvenile crab mortality.

### Growth

11. For all species, verify shell aging criteria using independent methods of shell age (e.g., radiometric aging, durometer, and tagging) and develop consistent and meaningful

criteria of shell aging in the field (Bering Sea snow and Tanner crabs; Southeast Alaska Tanner crab).

12. Develop a retainable tag for Tanner and snow crabs that is readily detectable.
13. Estimate the growth increment of crabs (Bering Sea snow and Tanner crabs; Central Gulf of Alaska Dungeness crab; Southeast Alaska golden and red king crabs; Other Tanner crab stocks).
14. Estimate molt probabilities and timing of crabs (Southeast Alaska golden king, red king, and Dungeness crabs; most Tanner crabs except Kodiak; Blue king crabs augment existing tag–recapture datasets to improve precision of current estimates).
15. Estimate annual variation in growth (molt increment and probability) and identify the causes of variation, particularly for stocks considered to be data-rich. Continue tagging experiments to obtain these data.
16. Evaluate the effects of individual characteristics (size, sex, maturity, and limb loss) on growth.
17. Evaluate the application of recent advances to age crabs such as lipofuscin density.
18. Determine meat fullness relative to last molt and assess factors that can affect meat fullness over time.

## REPRODUCTION

19. Study the temporal and geographic distributions of mature and immature males and females in relation to mating seasons, surveys, and fisheries.
20. Continue to study geographic and temporal changes in fecundity, egg predation, and size at maturity. Begin to understand the factors that cause these changes.
21. Assess the effect of annual/biennial spawning and multiparous/primiparous females on reproductive potential of crab stocks.
22. Use molecular genetic approaches to understand mating structure and paternity and how they affect the genetic effective size of crab stocks.
23. Continue to study the effects of body size, sex ratio, shell condition, and sperm storage on reproduction.
24. Examine the relationships among clutch fullness, exploitation rate, and mating ratio.
25. Evaluate and improve morphometric criteria for determination of male maturity and investigate spatial and temporal variation in these criteria.
26. Examine environmental effects on gonadogenesis, embryo development rates, and hatching success.

## SETTLEMENT AND RECRUITMENT

27. Identify and assess mechanisms that control juvenile abundance from settlement to recruitment to the fishery. Possible mechanisms include intra- and interspecific predation and competition, habitat availability, prey abundance, physical factors, and indirect effects.

28. Develop stock recruitment relationships for additional Alaskan crabs and evaluate factors that can lead to variation in the relationship.
29. Continue to investigate the periodicity in the frequency of strong year classes.
30. Determine larval durations and assess factors that can affect both duration and survival (e.g., rearing temperature, advection, feeding success, predation) and whether larval abundance or condition affects the likelihood of successful cohorts.
31. Determine larval dispersal patterns. Potential methods include 3-dimensional ocean modeling accounting for larval behavior, using surrogate larvae (e.g. gastropods) that can be tracked using microchemical or genetic signatures, genetic assays for larval crab and direct larval observations.
32. Estimate age of recruitment of juvenile Tanner crabs to the fishable stock.
33. Develop collectors that can sample larvae as they are settling from planktonic to benthic stages, use these to estimate settlement rates and investigate the feasibility of using settlement indices as an index of recruitment (Southeast Alaska Dungeness crab).

## HABITAT

34. Identify and map critical habitats for juvenile crabs from settlement to recruitment to the fishery. For some species this may involve a combination of bottom habitat features and oceanographic conditions such as temperature (Bering Sea snow crab, Southeast Alaska golden king and Tanner crabs).
35. Effects of variability in the physical environment (climatic change) on crab distributions, abundance, and life histories (Bering Sea king, Tanner, and snow crabs).
36. Identify physical and biological community associations by life history stage for red, blue, and golden king crabs and how these associations affect post-settlement processes.
37. Identify and map adult habitats including areas used during critical life stages such as molting and mating. Identify the key elements of these habitats to understand why crabs use those habitats (Pribilof Islands blue king crab, Southeast Alaska golden king and Tanner crabs).
38. Estimate the effects of pot fisheries on crab habitats, including long-lined pots in coral and sponge habitats.

## DISEASES AND PARASITES

39. Continue to monitor and study crab diseases (e.g. *Hematodinium* and leatherbacks) to determine life histories of these organisms, modes of transmission, crab mortality, and possible density-dependent relations to stock size. Evaluate appropriate harvest strategies for infected populations.
40. Devise strategies to minimize the spread and effect of diseases.
41. Investigate use of populations affected by disease via food technology research.

## FISHING-RELATED EFFECTS

42. Estimate bycatch and mortality due to trawling and dredging and ghost fishing.

43. Continue handling effects and bycatch mortality studies and include studies on the long-term effects of sublethal injuries.
44. Continue to collect observer data on crab injuries and document handling methods used by the commercial fleet.
45. Document natural background levels of crab injuries in stocks for which new fisheries develop and in stocks that have not been fished for years or that are now closed.
    a. Some Kodiak Tanner crab districts.
    b. Adak red king crabs.
    c. Glacier Bay red king and Tanner crabs.
46. Estimate the effects of displacement of female and sublegal male crabs from their preferred habitats or home ranges, particularly for species living along the steep continental slope habitats (e.g., grooved Tanner crabs, golden king crabs).
47. Increase observer coverage in groundfish fisheries to obtain better estimates of bycatch - (Gulf of Alaska red king crab).
48. Estimate the effects of crab injuries, such as limb loss, on predation rates by amphipods, fish, and other predators.
49. Assess the effectiveness of current bycatch reduction measures (i.e. escape mechanisms) and ghost-fishing reduction measures (i.e. pot limits and biodegradable lines). Develop improvements to these measures.
50. Determine the effects on long-term stock productivity of fishery selection by location, size, and shell condition.

# HARVEST STRATEGIES

## GEAR STUDIES

1. Continue studies on types of degradable devices (e.g., galvanic timed-release mechanisms, cotton twine) and their placement in pots.
2. Study pot degradation rates *in situ*.
3. Continue study of pot and trawl gear modifications (e.g., mesh size, escape panels and rings, Tanner boards, or sex-specific bait) to reduce bycatch.
4. Study the effect of pelagic pollock trawls with large mesh lower panels that are fished on the seafloor in crab habitats less than 50 fathoms in the eastern Bering Sea.

## HARVEST POLICY

5. Consider development of harvest strategies and population modeling amenable to biennial, triennial, other infrequent survey schedules. Consider inclusion of auxiliary data, such as observer data.
6. Continue to estimate biological reference points for Alaskan crab stocks, especially for data-poor stocks.
7. Develop ecological modeling approaches to better understand how to implement ecosystem considerations in harvest policies.

8. Evaluate alternative harvest strategies with respect to population dynamics and management implications. Alternative harvest strategies can include threshold spawning biomass, exploitation rate, constant catch, female harvest, minimum size limits, slot size limits (restrict pot tunnel entrances to prevent the largest crabs from entering the pot), multi-species harvesting, rotational harvests, and spatial closures.
9. Assess current harvest strategies and practices and implement new regulations and practices where necessary. This can include reevaluation of definitions, assessment of localized depletion, and review of stock thresholds as examples.
10. Evaluate the potential disproportionate benefits of large males and females with current harvest practices that remove the largest males from the population.
11. Evaluate sex, size, and seasonal management and develop new ways to manage unsurveyed stocks while preventing overfishing.
12. Improve estimates of personal use harvest rates (Southeast Alaska Dungeness, golden king, red king, and Tanner crabs).
13. Determine sustainable harvest thresholds, harvest rates, and model optimal economic returns (Southeast Alaska Dungeness crab).
14. Develop electronic logbooks and increase utility by recording soak times, gear descriptions, and more precise pot locations (Southeast Alaska golden king crab).
15. Use management experiments to investigate the use of spatial harvest strategies and fishery timing to reduce harvest rates, decrease lost productivity due to handling mortality, and allocate between user groups (Southeast Alaska Dungeness crab).